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AN INEXPENSIVE METEOROLOGICAL RADIATION SHIELD FOR THERMISTORS AND THERMOCOUPLES

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ABSTRACT

An inexpensive, easily fabricated meteorological radiation shield for thermistors or thermocouples is described. Comparisons made with standard wooden "Cotton Region" type shelters showed good agreement.

Keywords: Temperature, measuring equipment, thermistors, thermocouples.

INTRODUCTION

Many biological research and management activities require ambient air temperature measurements. It is also often desirable to make temperature measurements which are not affected by solar radiation. Comparability with standard wooden National Weather Service "Cotton Region" shelter or Stevenson screen measurements is often desirable or necessary. Wooden instrument shelters are costly and usually impractical to install in intensive sampling networks when only ambient temperatures are desired. Commercial radiation shields for use with thermistors or thermocouples are often too expensive in any quantity for many budgets.

This note describes a low-cost radiation shield. The shield is easily fabricated from locally obtainable items. Comparability and accuracy of this device are well within the range of several standard temperature transducers normally exposed in the classical wooden instrument shelter.

RADIATION SHIELD

The shield is basically a naturally ventilated variety. Several versions were constructed, one model fabricated from small aluminum pans, another from miniature aluminum piepans, and one version from small anodized aluminum ashtrays. The ashtray model was selected for field use primarily for esthetic reasons (fig. 1).

Figure 1.—Three models of radiation shields: left to right, small pan model, miniature piepan model, ashtray model.

CONSTRUCTION

We found that four pans or ash-trays made the shield deep enough, but five miniature piepans were necessary to insure adequate depth of the assembly. Aluminum bar stock, 3/4 by 1/8 inch and approximately 2 feet long (minimum), is needed for the braces, main support, and bottom radiation shield bracket (optional). The remaining materials are aluminum "pop rivets," backing washers, coathanger wire, primer, and paint.

Cut the aluminum bar into two 5-inch, one 4-inch, and one 10-inch (or longer) pieces. Using an appropriate size hold saw, cut the bottoms out of all but one of the pans. Drill three equally spaced holes in the pan rims. The pan edges can be bent down or flattened at the drilling point to facilitate this process. Determine the vertical distance between the holes in the pans while they are loosely nested. Drill the 10-inch and the two 5-inch bars to support the pans, as shown in figure 2.

The cutout bottom of one of the pans may be used as an optional bottom shield. Attach this bottom shield with the remaining 4-inch bar bent into an "L" bracket with pop rivets. A support for the thermistor or thermocouple is made from a piece of coathanger or other stiff wire. The wire should be long enough to secure to the main support by threading through two holes

Figure 2.—Radiation shield parts ready for assembly, and an assembled model with a thermistor attached. 1—piepans, 2—braces, 3—main support, 4—"pop rivets" and washers, 5—bottom radiation shield and mounting bracket (optional), 6—thermistor or thermocouple mounting bracket.

about 1 inch apart and then reaching up into the middle of the radiation shield.

After it is assembled, the shield should be primed and painted with a gloss white enamel or lacquer. Sufficient coats of paint should be applied to insure an even and durable finish.

COMPARISON TESTS

A wooden "Cotton Region" shelter, three versions of the radiation shield, and an aluminum instrument shelter were fitted with thermistors to evaluate the radiation screens and compare them with a standard exposure. The five thermistors were fed into a 16-point sequencing Grant recorder.[1/] Observations were recorded hourly, and all five points recorded within 40 seconds for about a 2-week period in late May.

The Cotton Region shelter (fig. 3) was accepted as a standard and the other four shields were compared with this standard in a series of

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[1/] *Use of brand names is for the convenience of the reader and does not necessarily indicate endorsement by the U.S. Department of Agriculture.*

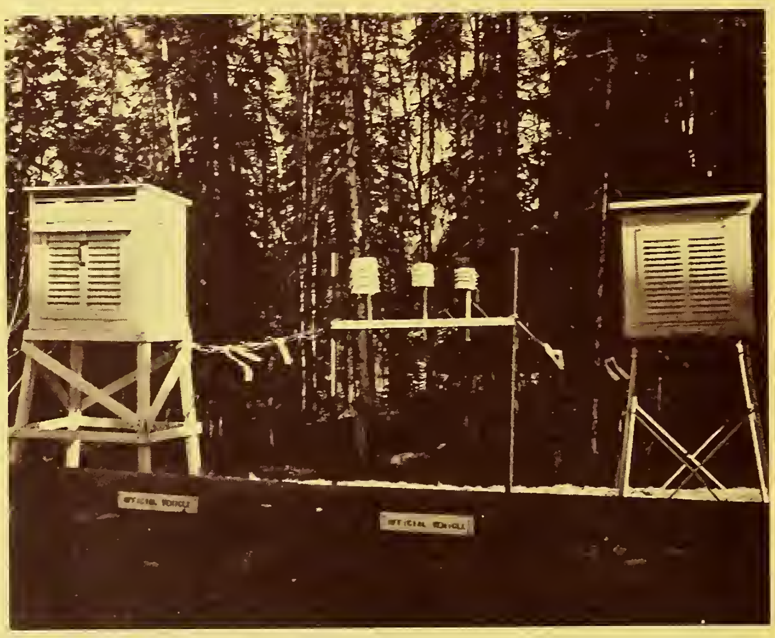

Figure 3.—Comparative test arrangement. Left to right, Cotton Region shelter, pans, miniature piepans, ashtrays, and aluminum instrument shelter.

chi-square accuracy tests.[2/] For these tests it was specified that the other shield would be acceptable if it could give temperatures which would be within 1.0° C. of the standard at the 95-percent probability level. All the other shields qualified under these criteria. None of the other shields qualified when the 1.0° C. criterion was reduced to 0.5° C.

Another field test was run in a different location using random observations over a 3-month summertime period, May through July. These data were used to compare the three radiation shields we built with the aluminum instrument shelter to see if they behaved similarly. Measurements were made with a Yellow Springs telethermometer calibrated in degrees F. The instrument was quite accurate and readable to 0.5° F. All three of our own radiation shields were within the ±1° F. (P=0.95) accuracy limitation established for the analysis when compared with the large aluminum shelter. Therefore, we assume the same general response characteristics in both our radiation shields and the aluminum shelter.

In a detailed report discussing the aluminum weather instrument shelter, the Forest Service compared this shelter with the standard Cotton Region type.[3/] Their results showed an increase in dispersion at daily maximum temperatures up to +2° F. and less than ±0.5° F. variation at minimum temperatures. Between 0° and 50° F., the aluminum shelter gave 1° F. higher readings than the standard Cotton Region shelter, and the difference was 2° higher between 51° and 100° F. This same general relationship also appears to exist with our radiation shields. Vogel and Johnson,[4/] in their tests of an aluminum shelter versus the standard wooden shelter, showed that greater differences occurred at the higher temperatures. Their aluminum shelter also gave generally higher readings than the wooden shelter. Essentially, the wooden shelter acts as an insulator and apparently responds less rapidly to temperature changes than do aluminum shields. Figure 4 shows the average dispersion by time of day and temperature established for the Cotton Region shelter. These deviations are well within the accuracy limitation of most of the standard temperature devices. Usually the accuracy of these instruments is ±1° C. or F.

2/ *Frank Freese. Testing accuracy. Forest Sci. 6: 139-145, 1960.*

3/ *USDA Forest Service. Aluminum weather instrument shelter. Missoula, Mont., Equip. & Test. Center, ED&TC Rep. 5100-13, 10 p., illus., 1964.*

4/ *T. C. Vogel and P. L. Johnson. Evaluation of an economical instrument shelter for microclimatological studies. Hanover, N.H., U.S. Army Cold Reg. Res. & Eng. Lab. Spec. Rep. 84, 4 p., illus., 1966.*

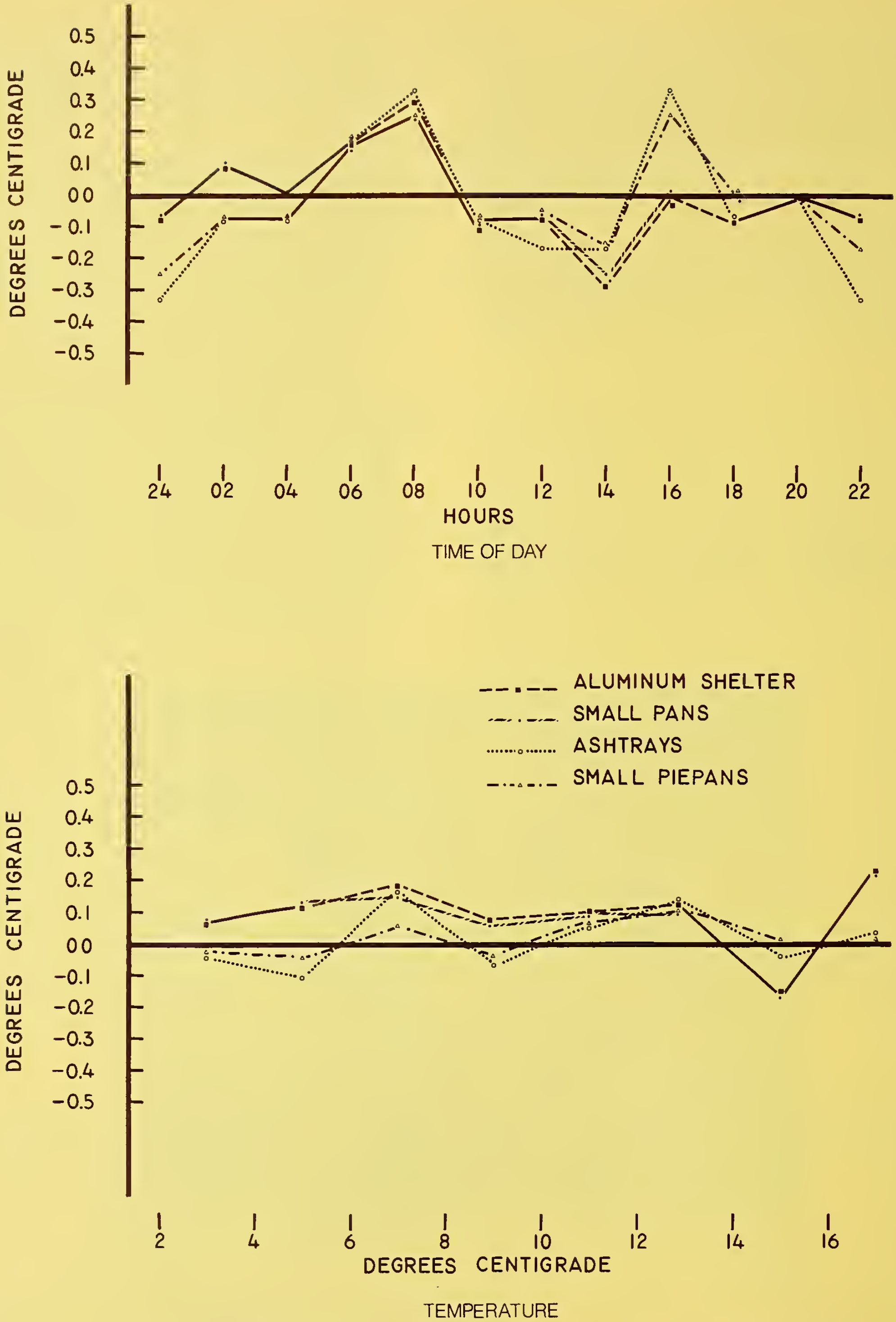

Figure 4.—Average temperature deviation for each of the four radiation shields as they vary from the Cotton Region shelter by time of day and temperature. The horizontal black line at zero represents the Cotton Region shelter temperature. (Note: When two or more traces coincided, a black line was used in plotting.)

SUMMARY

The inexpensive radiation shields discussed meet the requirements and standards of many research and management applications. Their low cost, ease of assembly, and general agreement with the standard radiation shields qualify them for repetitive temperature measurements in the field.

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